Ruppia megacarpa (Ruppiaceae): a new species to the floras of Japan, Korea, and Russia

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ABSTRACT

Ruppia L. is the only genus in Ruppiaceae that is primarily distributed in brackish water. A previous molecular phylogenetic work revealed that 2 non-flowering *Ruppia* specimens from Japan and Russia were genetically identical to *Ruppia megacarpa* R. Mason, a species previously known only from Australasia. To update East Asian floras, our study examined flowering specimens of putative *R. megacarpa* from East Asia, including the localities where the non-flowering specimens originated, and assessed their morphological characters by comparing them with those of the *R. megacarpa* holotype from New Zealand as well as morphological data obtained from the protologue and other systematic works. The three East Asian specimens exhibited slightly different quantitative morphology compared with the holotype; however, the values were mostly within the species variation. The species distribution was accordingly revised.

Keywords

Aquatic plants, Japan, Korea, *Ruppia megacarpa*, Ruppiaceae, the Russian Far East

РЕЗЮМЕ

Ито Ю., Охи-Томе Т., Скрипцова А.В., Сасагава М., Танака Н., Мура-
та Дж. *Ruppia megacarpa* (Ruppiaceae) – новый вид для флор Японии,
Кореи и России

Ruppia L. – единственный род в семействе Ruppiaceae, чьи представители распространяются преимущественно в солоноватой воде. Предшествующие исследования по молекулярной филогении рода показали, что 2 нецветущих образца *Ruppia* из Японии и России были генетически идентичны *Ruppia megacarpa* – виду, ранее известному только из Австралии. Для уточнения видового состава рода в Восточной Азии были исследованы образцы цветущих растений предполагаемого вида *R. megacarpa*, в том числе собранные в местообитаниях, откуда взяты нецветущие экземпляры, а также был проведен сравнительный анализ их морфологических признаков с голотипом *R. megacarpa* из Новой Зеландии и с морфологическими данными, приводимыми в протоколах других систематических работ. Три образца с Восточной Азии имеют незначительные количественные отличия в морфологии в сравнении с голотипом, однако, отклонения не выходят за рамки внутривидовой изменчивости. Таким образом распределение данного вида существенно уточнено.

Ключевые слова

водные растения, Япония, Корея, *Ruppia megacarpa*, Ruppiaceae, российский Дальний Восток

INTRODUCTION

Ruppia L. is the only genus from the aquatic family Ruppiaceae, which is primarily distributed in brackish waters. The taxonomic confusion surrounding this group resulted from its simple morphology, polyploidy, and worldwide distribution, preventing achievement of consensus regarding the infrageneric taxonomy (reviewed in Ito et al. 2010). Molecular phylogenetic analyses using plastid and nuclear DNA markers have dramatically resolved this issue and proposed a new classification of three morphologically and genetically distinct species: *Ruppia megacarpa* R. Mason (1967), *R. polycarpa* R. Mason (1967), and *R. tuberosa* Davis & Tomlinson (1974). In addition, a morphologically diverged

but genetically clustered species complex, *R. maritima* L. (1753), has been identified (Ito et al. 2010).

Phylogenetic analyses of some non-flowering specimens from East Asia revealed genetic sequences identical to *Ruppia megacarpa* from Australia (Ito et al. 2010). This species was described in New Zealand (Mason 1967) with larger fruits, well-coiled peduncles, branched to zigzag stems, and bidentate to truncate leaf tips, and believed to be endemic to the southern region of Australasia (Jacobs & Brock 1982, 2009), and thus, not listed in East Asian floras.

The aim of this study was to add *Ruppia megacarpa* to East Asian floras through morphological examination of relevant specimens from the area. For this purpose, herbarium surveys

were conducted to locate flowering specimens of putative *R. megacarpa* from East Asia, including those localities where genetically confirmed, non-flowering specimens were collected (Ito et al. 2010). Morphological evaluations were conducted, and the results were compared with the *R. megacarpa* holotype and the specimen reported in the protologue as well as that from other taxonomic literature. Based on these findings, *R. megacarpa* distribution was revised.

MATERIALS AND METHODS

Taxon sampling

Herbarium surveys were conducted to locate flowering specimens of putative *Ruppia megacarpa*, focusing on Japan and Russia where non-flowering *R. megacarpa* were previously collected (Ito et al. 2010). Two flowering specimens were located: Sasagawa 5380-a (Niitsu Shokubutu Shiryoushitu) and Skriptsova-2013-001 (Institute of Marine Biology, Far Eastern Branch of the Russian Academy of Sciences). To understand the actual distribution in East Asia, additional herbarium surveys were conducted that focused on other East Asian countries. A relevant specimen from Korea was identified (*Faurie no.* 225 [KYO]; Fig. 1). The *R. megacarpa* holotype from New Zealand was included as a comparative specimen (*J. Clarke 150818A* [CHR]).

Morphological assessment

The three East Asian flowering specimens of *Ruppia megacarpa* and the holotype from New Zealand were examined with special reference to reproductive characters and compared with those reported in the protologue and other taxonomic literatures (Mason 1967, Jacobs & Brock 1982, 2009). The length of peduncles, pedicels, and leaves of each specimen were measured using the ImageJ software (Abramoff et al. 2004).

RESULTS

The flowering *Ruppia megacarpa* specimens from East Asia exhibited branched-stem pattern, bidentate leaf tips, leaves of 5.5–14.5 cm length, well-coiled peduncles 10.5–

20.1 cm in length, fruits 2.9–3.5 mm in size, if matured, and four carpels (Table 1). The morphological characters obtained from the holotype of *R. megacarpa* included: branched-stem pattern, bidentate leaf tips, leaves of 4.6–19.6 cm length, well-coiled peduncles 17.5–33.4 cm in length, fruits 3–3.8 mm in size, if matured, and four carpels (Table 1).

DISCUSSION

The flowering specimens of *Ruppia megacarpa* from East Asia exhibited diagnostic characteristics of the species, such as bidentate leaf tips, four carpels, and a larger fruit size (Mason 1967, Jacobs & Brock 1982, 2009, Zhao & Wu 2008). Some morphological differences were observed in quantitative characters between the three East Asian specimens and holotype, such as peduncle length and fruit size. However, these values were within the variations previously reported. Thus, the distribution of *R. megacarpa* was revised to include Japan, Korea, and Russia. Note that China is not included, even though *R. megacarpa* is recently reported (Yu et al. 2014) because one of the included specimens is described as having "an abortive inflorescence with anthers lacking pollens; the carpels were shrunken". Given that a sterile hybrid of *R. megacarpa* is reported from Hokkaido, Japan (Ito et al. 2010), which has only vegetative parts, this Chinese specimens might be not *R. megacarpa* but rather the hybrid.

Taxonomic treatment

Ruppia megacarpa R. Mason (1967; 525, f. 3).

Type: NEW ZEALAND, Taumatu: drift in Lake Ellesmere, 9 Feb. 1966, *J. Clarke 150818A* (holotype CHR!).

Chromosome number: $2n = 20$ (New Zealand [Mason 1967, Beuzenberg & Hair 1983]; Australia [Jacobs & Brock 1982, Snoeijis & Van der Ster 1983, Ito et al. 2010]; Japan [Ito et al. 2010]).

Distribution: Australasia (Australia, New Zealand), East Asia (Japan, Korea, Russia) (Fig. 2).

Additional specimens examined: JAPAN, Niigata, Kamoko lake, 6 Jun. 2006 (Niitsu Shokubutu Shiryoushitu:

Table 1. Morphological comparisons between the holotype of *Ruppia megacarpa* and East Asian specimens

Voucher	N/A ¹	<i>J. Clarke 150818A</i>	<i>Sasagawa 5380-a</i>	<i>Faurie no. 225</i>	<i>Skriptsova-2013-001</i>
Country of origin	N/A	New Zealand	Japan	Korea	Russia
Stem pattern	branched to zigzag	zigzag	branched	branched	branched
Leaf length (cm)	5–25	4.6–20.0	5.5–14.5	3.2–7.7	10.5–12.5
Leaf tip shape	bidentate to truncate	bidentate	bidentate	bidentate	bidentate
Peduncle length (mm)	10–30	17.5–33.4	10.5–20.1	12.2–15.4	12.2
Fruit size (mm)	(3-)4(-5)	3.2–4.9	3–3.8	3–3.5	N/A ²
Carpel number	(2-)4(-6)	4	4	4	4

¹After Mason (1967), Jacobs & Brock (1982; 2009), Zhao & Wu (2008)

²No mature fruits are observed

Figure 1 Voucher specimen of *Ruppia megacarpa* from Korea (Faurie no. 225; KYO).

Figure 2 Distribution of *Ruppia megacarpa*. Solid circles are based on Jacobs & Brocks (2009). The type and new localities are indicated with a star and open circles, respectively

5380-a); KOREA, Wonsan, 28 Jun. 1906 (KYO: *Faurie* no. 225; Fig. 1); RUSSIA, Hasan, Ptich'e (Talmi) Lake, 1 Jul. 2013 (Institute of Marine Biology, Far Eastern Branch of the Russian Academy of Sciences: Skriptsova-2013-001).

Note: *Ruppia megacarpa* is occasionally confused with *R. cirrhosa*, *R. occidentalis* ("Occidentalis" of the *R. maritima* complex; Ito et al. 2010), and *R. truncatifolia*. Of these, *R. cirrhosa* is distinguishable from *R. megacarpa* with leaf tip shape and the size of fruit; the former has round tip and 2.5 mm in length, while the latter has bidantate and 4–5 mm in length (Mason 1967). "Occidentalis" is distinguished by its (2–)8 carpels; those of *R. megacarpa* is usually 4 (Mason 1967, Ito et al. 2010). From *R. truncatifolia*, for which only vegetative rosette specimens are known, *R. megacarpa* is recognized by its zig-zag stem and well-set flowers and fruits. Note that the putative fruiting specimen of *R. truncatifolia* reported by Yamazaki et al. (2008) is a misidentification of «Occidentalis» as the specimen has round leaf tip and smaller fruit size.

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